

Reptiles and Amphibians from Nan Ao Island, China

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(Received 2 July 1998; revised and accepted 10 November 1998)

Abstract

Specimens of 18 native reptile and amphibian species were collected for the Department of Biology, Santou University, on Nan Ao Island, Guangdong Province, China. Four of five lizard species appear to be new records: *Gekko subpalmatus* (major range extension), *Ateuchosaurus chinensis* (we present life history data), *Eumeces chinensis* and *Sphenomorphus indicus*. All five snake species appear to be new records: *Typhlops* ("Ramphotyphlops") *braminus*, *Elaphe radiata*, *Natrix* ("Xenochrophis") *piscator*, *Oligodon formosanus* and *Trimeresurus cf. albolabris*. Five frogs and toads are species already recorded, but *Rhacophorus leucomystax* (*Polypedates megalcephalus*) and *Microhyla ornata* are newly recorded. A single *Bufo* specimen may represent a new species. *Rana catesbeiana*, introduced from America, is now established in the wild. The native *Rana rugulosa* was not found. Geological history, ecological conditions and habitat alterations are discussed.

Key words

Biogeography, Squamata, *Gekko subpalmatus*, *Ateuchosaurus chinensis*, *Trimeresurus*, *Bufo*, habitat alteration.

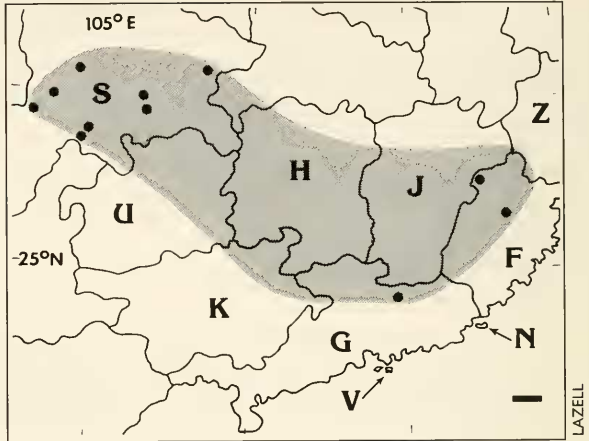
Introduction

Nan Ao is the largest island on the continental shelf of Asia between Taiwan and Hong Kong. Variously spelled "Nanngau" or "Namo," and translated to mean "south crescent beach" or "south bay," the island figured prominently in the history of western exploits in China (Williams 1895). However, little has been published on its natural history. In 1996, the Department of Biology, Santou University, began an exchange program with The Conservation Agency involving personnel, publications and specimens, many of which were deposited at South China Normal University, the University of Hong Kong, the Yale Peabody Museum (YPM) and the Museum of Comparative Zoology (MCZ). Here we report on recent reptile and amphibian collections made on the island.

Nan Ao is circa 106 square kilometers, with two rugged massifs on its eastern and western portions connected by an alluvial plain largely filled by the city of Houzhai. The western massif rises to 587 meters at Da Jian Shan, the high point of the island, and the larger eastern massif rises to 576 meters. Nan Ao is on the Tropic of Cancer at the eastern edge of Guangdong

Figure 1

A portion of South China showing the location of Nan Ao (N), Hong Kong (V), and an estimate of the range of *Gekko subpalmatus* on the mainland (shaded). Dots are locality records from Pope (1935) in the provinces of Sichuan (S), Guangdong (G) and Fujian (F); he also notes Zhejiang (Z) without precise locality. Zhao and Adler (1993) add the provinces of Guizhou (U), Guangxi (K) and Jiangxi (J). We are unaware of any record from Hunan (H). Lower right bar represents 100 km.



Province, and was historically portioned between Guangdong and Fujian, the neighboring province to the east (Figs. 1 and 2). The island is a remnant of the Zhe Min Oldland and has been largely above sea level since the Early Jurassic (Wang 1985), unlike the adjacent mainland, which is nearly flat and has been repeatedly submerged (as recently as the Sangamon interglacial, some 120,000 years ago).

Nan Ao's climate is monsoonal, resembling that of Hong Kong to the west (Dudgeon and Corlett 1994). The average temperature is 21.5°C. January is the coolest month, at the height of the northerly dry monsoon, with lows of 2.9–14°C. August is the warmest month, with highs of 27.5–36.5°C. Rainfall averages 1,348 mm per year, with most falling during the southerly wet monsoon from June through September. It rains an average of 2,290 hours per year, and the island is struck by an average of 19 cyclonic storms annually (YL, unpubl. data), notably more than Hong Kong (Dudgeon and Corlett 1994). The island was originally covered in evergreen monsoon forest, but only tiny remnants remain as *fungshui* woods on the edges of coastal towns, or as patches in the steeper inland

ravines. Even these remnants are selectively cut for valuable wood products and attain little more than shrub stage today. There are some tree plantations, largely of exotic *Eucalyptus* and American *Pinus*. Prior to 1950 Nan Ao had extensive mangrove swamps, but these have been converted to commercial salt works or filled for urban development.

Materials and Methods

We collected 267 specimens on 25 July 1996 and 13–23 July 1997 on Nan Ao and Wu Yu islands (Fig. 2). Our collecting was highly selective; we did not attempt to amass large series. We attempted to collect specimens that vouchered particular habitat types, individual variation, sizes and sexes. We did record in a bound field journal (JL) the presence of species seen but not collected. In 1996 we collected only on the Houzhai plain for one evening. In 1997 we spent four days canvassing the island for the most productive collecting sites (see Discussion below). Efforts to document the herpetofauna of South China and the islands of the South China Sea span two decades (Lazell and Liao 1986, Lazell 1988a, and works cited

therein and herein). Specimens were preserved in plastic trays and injected with a solution of one part stock formalin (37–41% formaldehyde in water; buffered) in 15 parts 70% isopropanol. They were maintained wet in the trays in 70% isopropanol (without formaldehyde) until firm, then transferred for storage to 60% isopropanol (*contra* Simmons in Zhao and Adler 1993). All specimens were tagged in the field and thus end up with two tags affixed, the second reflecting museum acquisition. Ventral scale counts on snakes were made by the method of Dowling (1951) so as to reflect number of trunk vertebrae. We also examined comparative material in the American Museum of Natural History (AMNH).

***Gekko subpalmatus* (Guenther)**

This species was quite unexpected on Nan Ao (Fig. 2:2, 5 and 7), and especially on Wu Yu (Fig. 2:8). Zhao and Adler (1993) include Guangdong in the range but we have seen no mainland specimens. Pope (1935) provides details of distribution indicating an upland and inland range (Fig. 1). In view of the apparent range dis-

junction, the paucity of available information on this species and subtle differences between populations, we provide a detailed description. We compared our specimens with AMNH 23586, 33018–21, 33025, 35157, 35160 and 39970, plus one untagged, from “mountains near Yeng Ping;” and with MCZ 45960–1 from “Chungan Hsien,” all inland Fujian Province (Fig. 1). For other species, we used the accounts of Zhou et al. (1989) and Ota et al. (1995), and examined 14 MCZ specimens of *G. chinensis* (Gray) from Hong Kong and mainland Guangdong. Data for all 21 specimens from Nan Ao (YPM 9094–7, 9105, 9158 and 9160–2) and Wu Yu (YPM 9111–22) are combined in the description below.

Ten males measured 48–63 (average 59) mm SVL and 11 females measured 46–79 (average 64) mm SVL. Head width measured 10.1–13.0 (average 12.2) mm for males and 9.7–16.0 (average 13.1) mm for females. Eye diameter measured 2.7–3.8 (average 3.2) mm for both sexes. In males, 7–10 (average 9) preanal pores are present, as well as a large cloacal spur on each side of the base of the tail. Supranasal scales are always in contact or



Figure 2

Nan Ao and adjacent islets. Contours are at 300 m and 500 m. Bar represents 1 km. T, right, indicates the Tropic of Cancer. Localities are: 1, Gui Chen; 2, Huanghua Shan Reservoir; 3, Houzhai city; 4, Bai Sha Wan; 5, Shen Ao; 6, Wu Ping Zai; 7, Tai Zhu Ao; 8, Wu Yu. Inset shows the position of Nan Ao (arrow) relative to the Chinese mainland (C), Hainan Dao (H), Taiwan (T) and Luzon, Philippines (L).

separated by a minuscule granule. There are no significant differences in the number of middorsal scales in eye diameter among populations, but there is a weak modal difference between the inland Fujian specimens and those from Nan Ao and Wu Yu. In the latter there are 12–21 (average 16) scales in eye diameter, while those from inland Fujian have 14–27 (average 19) dorsal scales in eye diameter. In the Nan Ao and Wu Yu specimens, especially those from Shen Ao, the head is tapered and somewhat pointed, rather than rounded as in material from inland Fujian (Fig. 3). The rostral is quadrangular and about twice as wide as high. In YPM 9097, from Shen Ao, there are scales present within the rostral borders anterior to the supranasals (Fig. 3); this individual is unique in this respect among all examined.

All mainland specimens we have seen are patterned in shades of brown, despite decades in alcohol. The first live Nan Ao *G. subpalmatus* we observed (YPM 9094–7) were gray dorsally, dirty yellowish abdominally, and with a “ladder” pattern especially well developed on the nape and shoulders (Fig. 4). On Wu Yu, live *G. subpalmatus* (YPM 9111–22) were mossy green to olive, banded with chocolate brown to tan. Abdominal yellow was reduced or absent, but throats often had yellow tones. The dorsal banding was regular, without the longitudinal “ladder” components. These specimens had a prominent cephalic “W” mark (Fig. 4), and could turn pale ashy gray and tan when captured.

G. subpalmatus from other Nan Ao localities were intermediate. For example, YPM 9158 from Huanghua Shan Reservoir approached Wu Yu specimens in pattern, with the cephalic “W,” but with the dorsal transverse bars less regular and more broken. There were no longitudinal

nape or shoulder bars. When first found, this individual was gray brown with conspicuous ash white dots, but after capture it turned shades of warm brown and the dots disappeared. At Tai Zhu Ao, YPM 9162 was colored in life in shades of lead to slate gray like the Shen Ao specimens. It lacked both the ladder pattern and cephalic “W.” Three more individuals (YPM 9105, 9160–1) showed varying degrees of both pattern elements, but little or no brown coloration.

***Hemidactylus bowringi* (Gray)**

This is the abundant, edificarian gecko of South China (Karsen et al. 1986), with numerous specimens in institutional collections from many localities, including small islands (Lazell 1988b, Lazell et al. 1997). We examined females YPM 9090 (49 mm SVL) and MCZ 181800 (50 mm SVL), both from Houzhai, and YPM 9093 (47 mm SVL) from Shen Ao. We saw these geckos at several other localities (Fig. 2:2 and 7). The Wu Yu series (YPM 9153–6) includes males 47 and 49 mm SVL, a 46 mm SVL female with two large, shelled eggs, and a 22 mm SVL juvenile (Fig. 2:8).

***Ateuchosaurus chinensis* Gray**

This is an uncommon lizard over most of its range (Karsen et al. 1986), but it sometimes occurs in numbers on small islands (Lazell 1994). All of our collected specimens (YPM 9101–2, 9108–10 and 9152) were found beneath rocks and logs at Huanghua Shan Reservoir (Fig. 2:2), but one individual was observed basking on 14 July 1997. Several were turned out from cover submerged in streams. A female, YPM 9108 (58 mm SVL), contained remnants of a grasshopper (Orthoptera: Acrididae). A male, YPM 9110 (61 mm

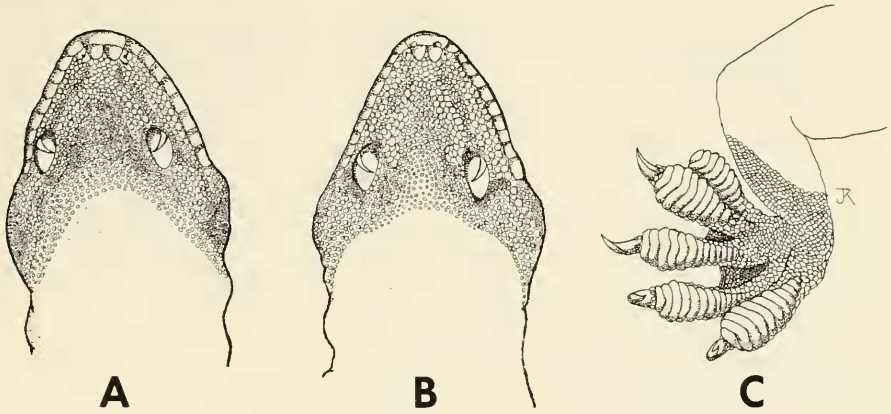


Figure 3

Gekko subpalmatus. A, MCZ 45960 from Fujian. B, YPM 9097 from Nan Ao. C, right pes, YPM 9097. Illustration © 1999 by Jonathan Kolby.

SVL), contained orthopteran eggs.

All three males (YPM 9102, 9110 and 9152) have 30 scale rows at midbody. One female (YPM 9109) has 30, and two (YPM 9101 and 9108) have 28. Midventrals ranged 61–64 (average 62) from just posterior to the mental to the edge of the vent in both sexes. Subdigital lamellae under the fourth (longest) toe of the pes were 16–18 (average 17) in both sexes. In life these *A. chinensis* were rich chestnut to mahogany brown dorsally with nearly black lateral fields containing bold, nearly white spots, with vinaceous tones anterolaterally on the head and neck. In males, the vinaceous color was especially bright, the throats bright orange and the bold light dots pale lime green to cream yellow.

In addition to the six from Nan Ao, we have available 14 specimens from seven islands and the mainland of the Hong Kong region (MCZ 112194, 172612–4, 172447–70, 176214–6, 176651, 177076 and 179514–5). Nan Ao female YPM 9109, collected 20 July 1997,

contained three shelled eggs measuring 12–14 by 7.5–8 mm. These eggs were arranged in the body cavity lengthwise, occupying (with the oviduct between them) more than 42 mm within a skink 75 mm SVL. The anterior egg thus extended far into the thoracic area. The viscera were much reduced in size and the abdominal muscle wall was noticeably thickened compared to other specimens. Both smaller females YPM 9101 (54 mm SVL) and YPM 9108 (58 mm SVL) contained ovarian eggs approaching 1 mm in diameter when collected 17 and 20 July 1997, respectively.

The ontograph for *A. chinensis* (Fig. 5) indicates year classes, implying seasonal reproduction (Auffenberg and Auffenberg 1989). The pattern, however, does not fit skinks from this region documented by Lazell et al. (1997) or Lazell and Ota (1998). The wide seasonal span shown by Okada et al. (1992) might account for this pattern, but we hypothesize that females spend the wet, warm monsoonal season yolking up eggs that hatch late in that

season. If our seasonal hypothesis is correct, females would probably not lay eggs until about 23 months of age.

***Eumeces chinensis* (Gray)**

Our sole voucher (YPM 9100) is an adult female 97 mm SVL collected in a wet paddy in the early evening of 16 July 1997 (Fig. 2:3). In life the specimen was similar to Hong Kong specimens, as in the photograph provided by Karsen et al. (1986): muddy gray brown with yellowish brown sides and rusty lateral blotches. However, juveniles of *E. chinensis* may be quite dark, nearly black, with bold light stripes and bright blue tails (e.g., MCZ 176225–9, Hong Kong region). We saw skinks that appeared to be typical adult *E. chinensis* (as YPM 9100 above) and that were dark, striped and blue tailed at Shen Ao on 20 July 1997. We saw several other dark, striped, blue-tailed skinks we believed might be *E. quadrilineatus* (Blyth) at Huanghua Shan Reservoir, on 17 July 1997, and twice near Tai Zhu Ao, on 16 and 17 July 1997.

***Sphenomorphus indicus* (Gray)**

Our larger specimen, YPM 9103 (72 mm SVL), was dark brown with a ragged nearly black lateral zone and similarly blackish blotches in the brown middorsal field. The chin and throat were nearly black and white. This bold pattern faded posteriorly along the ventral surface to coppery light yellow on the sides of the abdomen and around the vent. The underside of the tail was golden. There was a prominent series of light brown dash marks forming a dorsolateral stripe. Our smaller specimen, YPM 9107 (63 mm SVL), was similar but had what appeared to be solid deposits, bright yellow in

color, at the elbows, ankles and in the digits. *S. indicus* occurs on Hainan and Taiwan (Zhao and Adler 1993) and on the mainland in the Hong Kong region, but not on the larger islands of Hong Kong and Lantau (Karsen et al. 1986). It has been recorded from small islands of the Matsu Group (Ota and Lin 1997). Ours were collected in shady woods at Huanghua Shan Reservoir (Fig. 2:2).

***Typhlops* (“*Ramphotyphlops*”) *braminus* (Daudin)**

Our two vouchers of this parthenogenetic species (Fig. 2:1 and 2) have the typical 20 midbody scale rows; YPM 9091 is 122 mm SVL, tail 3 mm, with 315 ventrals in midline, chin to vent. YPM 9104 is 135 mm SVL, tail 3.5 mm, with 336 ventrals. This is an abundant species on islands of tropical China (Karsen et al. 1986, Lazell 1988b, 1994).

We follow Hahn (1977) in using *Typhlops* rather than “*Ramphotyphlops*,” and note that Wallach (1993) describes a continuum of morphology. The genus “*Ramphotyphlops*” was diagnosed solely on the hemipenes, structures of males only, so not present in *T. braminus*.

***Elaphe radiata* (Schlegel)**

Our voucher (YPM 9159) is an adult male circa 1.7 m in life, prepared as a skin and complete skeleton. There are the normal 21 scale rows at the nape, 19 at midbody and 17 just anterior to the vent. There are 227 ventrals and 95 subcaudals (tail perfect). These counts are low compared to those given by Pope (1935): 228–231 and 95–101, respectively, for males, or to ventral counts (225–246) given by Hu et al. (1980). However, Wu et al. (1985) provide a table with several males having fewer

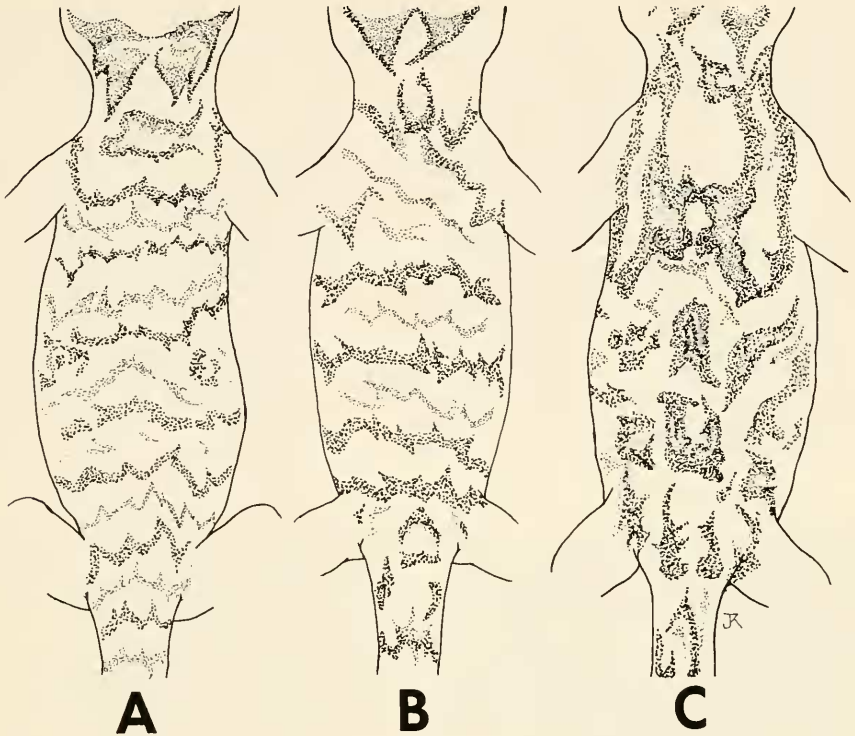


Figure 4

Gekko subpalmatus dorsal patterns. A, MCZ 45960 from Fujian. B, YPM 9120 from Wu Yu. C, YPM 9097 from Shen Ao, Nan Ao. Illustration © 1999 by Jonathan Kolby.

than 227 ventrals, including one with 221. The subcaudal count is near their median, 86–101. In life YPM 9159 was somber, dark gray brown posteriorly, striped with dull gray tan anteriorly. There were slate black blotches in the dorsolateral fields trimmed with cream white to ash gray. The venter was pink anteriorly, with gray increasingly encroaching ventrolaterally, and cloudy gray posteriorly. This highly active, diurnal snake is known as the “copperhead racer” in the Hong Kong region and is common on the larger islands like Hong Kong itself and Lantau (Karsen et al. 1986). We trapped ours at Tai Zhu Ao using paddy frogs for bait (Fig. 2:7).

***Natrix* (“*Xenochrophis*”) *piscator* (Schneider)**

All of our specimens (YPM 9092, 9099 and 9157) are males (Fig. 2:1, 2 and 3). Two are certainly young of the year: YPM 9099, 127 mm SVL (tail 51 mm), collected 16 July 1997 at Houzhai; and YPM 9157, 131 mm SVL (tail 55 mm), collected 21 July 1997 at Huanghua Shan Reservoir. However, neither of these small specimens shows a yolk sac scar, so we do not refer to them as hatchlings. Our Gui Chen specimen (YPM 9092) was captured in the act of swallowing a paddy eel, *Fluta alba* L., unfortunately not measured or preserved.

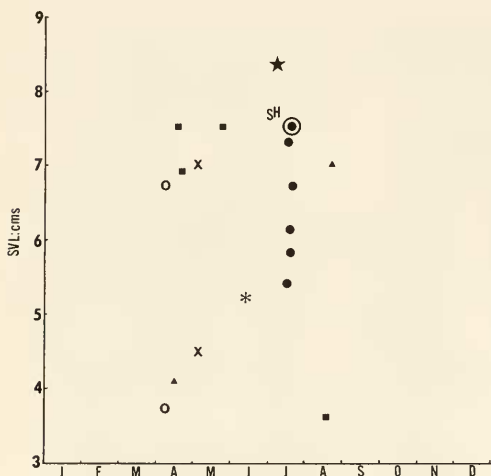


Figure 5

Ontograph of *Ateuchosaurus*. Solid dots, Nan Ao; the circled dot is gravid female YPM 9019. Hong Kong region: squares, Lantau Island; circles, Peng Chau; triangles, Ma Wan Island; X, Ngong Shuen Chau (Stonecutters Island); asterisk, Lam Chau (now destroyed); star, Ping Chau; H, Hong Kong Island; S, Sai Kung Peninsula.

All three have the normal dorsal scale row counts: 19 nape, 19 midbody and 17 before the vent. Two have 124 ventrals (YPM 9092 and 9099); one has 125 ventrals. Subcaudal counts vary considerably: YPM 9092 has 54, lower than the range of 67–88 given for males by Hu et al. (1980). The tail is 107 mm, one third of SVL, which is 324 mm; this is shorter than the mode of circa 40% in most males. The tail ends in a spine-like scale and does not appear damaged, but we opine it must have been truncated. Subcaudals number 80 in YPM 9099 and 73 in YPM 9157.

Zweifel (1960) noted that snake populations on the offshore islands of Pacific Mexico had consistently higher ventral counts (and therefore more trunk vertebrae) than their mainland relatives. He compared populations of 10 species, and suggested that the constant shift was “possibly not determined genetically.” Zweifel (1960) did not speculate on what environmental condition of those islands might cause high ventral counts. We note that ventral counts of our *N. piscator*, like that of *Elaphe radiata* above, are near the low extreme for males of their species,

122–138 (Hu et al. 1980). We suggest that cold ocean currents in the eastern Pacific may lower the average incubation temperatures on Zweifel’s Mexican islands, while the warm waters of the South China Sea might warm island temperatures along the coasts of tropical China.

Oligodon formosanus (Guenther)

An adult male (YPM 9098) was captured alive on 16 July 1997, and an adult female was found dead on a road on 22 July 1997, both at Tai Zhu Ao (Fig. 2:7). The male has 19 dorsal rows at nape and midbody, 15 before the vent; the female has 19 at nape and midbody, but 17 before the vent. The male has 161 ventrals and 51 subcaudals; ranges for males from Hu et al. (1980) are 159–167 and 46–55, respectively. The female has 171 ventrals and 46 subcaudals; ranges for females from Hu et al. (1980) are 156–173 and 39–51, respectively. Both snakes were patterned in somber shades of gray brown. The male in life was bright rose pink on the posterior venter; this color faded to nearly white anteriorly and under the tail. The female

had only a faint tint of posteroventral pink, possibly as a result of postmortem fading. Pink posterior ventral color is typical (Hu et al. 1980). The male had a yellowish chin and throat. *O. formosanus* is a regular inhabitant of tropical China's islands such as Hong Kong and Lantau (Karsen et al. 1986), and even some no larger than Ping Chau, circa 0.7 square kilometers (Lazell 1994).

Trimeresurus cf. albolabris (Gray)

This is our most notable snake, YPM 9151, found alive on the road, but mortally wounded, at 2000 hrs, 22 July 1997, at Wu Ping Zai (Fig. 2:6). The specimen is a subadult male, SVL 360 mm, tail 95 mm; the hemipenis is partially everted on the right and the left has been dissected. There is an anomalous half ventral just before the anal plate. Table 1 lists some characters of this individual, compared to *T. albolabris* and *T. stejnegeri* Schmidt, the other two green "bamboo" vipers of South China. As in both *T. albolabris* and *T. stejnegeri*, YPM 9151 has the nasal scale in broad contact with the plate forming the anterior border of the pit, and a separation of the supraoculars by 12 smooth, subimbricate scales (variation 8–13, both species). The dorsals are keeled, and there are the usual 21 rows at midbody. There are 72 subcaudals (male range: 65–73 in *T. albolabris*, 68–74 in *T. stejnegeri*). The hemipenes are not fully developed, but the sulcus is already prominent. There are three large, although still soft, spines at the base of the fork on each member.

In life this snake was bright green with a brilliant yellow belly and supralabials; there were very faint, shadow-like dark transverse markings, but these appear more prominent in preservative. The

upper half of the first dorsal scale on each side was bold lime white, forming a nearly continuous stripe along the side. The tail top was russet. The morphology accords well with *T. albolabris* from Guangdong and Hong Kong. However, in life the lower half of the first dorsal scale on each side was brick red. The iris was similarly brick red, notably darker than in *T. albolabris*. In both color characters YPM 9151 agrees with *T. stejnegeri*. The presence of developing spines on the immature hemipenes is unlike *T. albolabris* and accords with *T. stejnegeri* (Pope 1935).

Bufo melanostictus Schneider

This is the abundant toad of South China and nearby coastal islands, documented on Nan Ao by Li and Pan (1995). We took a large female, YPM 5471 (89 mm SVL), as a voucher at Tai Zhu Ao, 23 July 1997, and note MCZ 125859 from Houzhai. Sight records are from Fig. 2:2 and 5.

Bufo sp. indet.

We here call attention to a peculiar subadult toad (Fig. 6) from Houzhai (Fig. 2:3), MCZ 125860, 35 mm SVL, that was exchanged as *Bufo gargarizans* Cantor on geographic grounds. It certainly is not that species. In life it was patterned entirely in soft browns, without dark spines or crest edges, or any blackish coloration dorsally, but with dark ventral spotting. The cranial crests, albeit weakly developed, are unlike either the South China *B. gargarizans* or *B. melanostictus*. Professor Li Zhen-chang visited MCZ on 19 August 1998 and compared this individual directly to the Chinese *Bufo* and the several American species sympatric with *Rana catesbeiana*. We suspected it might have been introduced inadvertently with

eggs. We are satisfied, however, that it differs strikingly from all these forms. We await collection of additional specimens.

***Rana catesbeiana* Shaw**

American bullfrogs, vouchered by YPM 5521–3 and collected in the wild at Houzhai on 15 July 1997, and at Bai Sha Wan on 23 July 1997, are now well established on Nan Ao (Fig. 2:3 and 4). They were introduced as a commercial venture for food. We were informed locally that three “kinds” have been imported: “American bullfrogs, Cuban bullfrogs and river frogs.” We have seen only *R. catesbeiana*, but that species is notorious for eating other frogs and is implicated in the decline and local extirpation of several species native to areas where exotic *R. catesbeiana* has been introduced and become established (Hayes and Jennings 1986).

***Rana guentheri* Boulenger**

This species is common on South China Sea islands like Hong Kong and Lantau (Karsen et al. 1986) and documented on Nan Ao by Li and Pan (1995). We collected YPM 5526–7 at Houzhai, YPM 5529–32 at Shen Ao, and YPM 5528 at Tai Zhu Ao between 13–20 July 1997 (Fig. 2:3 and 7). These frogs are somewhat different from those we are accustomed to elsewhere in Guangdong and in the Hong Kong region. They are noticeably less red brown, tending to dark mustard or olive brown. They have lustrous, metallic looking platinum to gold upper lips and folds from tympanum to shoulder, much more prominent than usual elsewhere. Four males are 65–74 (average 68) mm SVL and three females are 61–74 (average 69) mm SVL. Males are easily recognized by their wrinkled lateral throat vocal sacs.

***Rana limnocharis* Boie**

The paddy frog is the most abundant frog at present on Nan Ao. We put up 12 voucher specimens (YPM 5549 and 5551–61) and recorded them at six localities (Fig. 2: western tip, 1, 2, 3, 5 and 7). We used this species frequently for bait. It is common on South China Sea continental shelf islands, including some rather small ones (Lazell 1988b), and is documented on Nan Ao by Li and Pan (1995). Our specimens measured 28–49 (average 38) mm SVL; only the largest appeared reproductive, a gravid female. Of a pair of adults from Houzhai collected 25 July 1996, the male (MCZ 125857) measured 32 mm SVL, and the female (MCZ 125858) measured 41 mm SVL. The sexes are easily distinguished by the sooty black patches on the throat sides of males.

Three striking pattern variants of *R. limnocharis* vary geographically in frequency: unstriped, narrow striped and broad striped middorsally (Ota and Lin 1997). Of 14 from Nan Ao, seven are unstriped, four have narrow stripes, two have broad stripes and one is anomalous. On the anterior half of the trunk of YPM 5556 the middorsal stripe is broad; at midbody there is a sharp bend to the left, the stripe makes an acute angle, and resumes its middorsal position as narrow on the posterior trunk. Only color pattern seems anomalous in this individual. There is no obvious scar tissue and the longitudinal rugosities are symmetrical and appear normal, even within the bent stripe area.

***Rhacophorus leucomystax* (Gravenhorst) or *Polypedates megacephalus* Hallowell**

This brown tree frog was not recorded on Nan Ao by Li and Pan (1995). Taxo-

Table 1

	Nan Ao	<i>T. albolabris</i>	<i>T. stejnegeri</i>
Supranasal and nasal	fused	fused	separate
Internasals	in contact	in contact	separate
Dorsal rows at nape	21	21–27	21–23
Dorsal rows at vent	17	15	15
Ventrals	154.5	153–162	161–171
Belly color	yellow	yellow	green
First dorsal color	white/red	white/green	white/red
Transverse bars	present	present	absent
Hemipenial spines	3	none	many
Hemipenial sulcus	prominent	prominent	weak
Iris color	brick red	pale red	brick red

Some characteristics of male South China green “bamboo” vipers. Data from Pope (1935) or Hu et al. (1980) except for the Nan Ao specimen, YPM 9151.

onomic uncertainty, from family through species level, is noted by Lazell et al. (1997). Our vouchers, YPM 5604–6 and 5608–9, from Houzhai and Tai Zhu Ao, respectively (Fig. 2:3 and 7), measured 47–66 (average 54) mm SVL; the largest is a gravid female, YPM 5604, collected in amplexus with YPM 5605, 13 July 1997. Brown tree frogs are abundant on Hong Kong (type locality of *P. megacephalus*), Lantau and many smaller coastal islands (Karsen et al. 1986, Lazell 1988b, Lazell et al. 1997).

***Kaloula pulchra* Gray**

First recorded on Nan Ao in July 1996 (Lazell and Lu 1996), the “painted frog,” “Malaysian narrowmouth toad” or “underground ox” is abundant in the remaining wetlands on the Houzhai plain, but we did not encounter it elsewhere (Fig. 2:3). We have noted the ability of these frogs to survive urbanization, living in gardens and parks and breeding in storm drains in

Houzhai and Hong Kong. Although their occurrence is spotty, they inhabit some small islands (Lazell et al. 1997). In addition to the vouchers in China and MCZ, we have YPM 5497, a 55 mm SVL male.

***Microhyla pulchra* (Hallowell)**

This “pygmy” frog is one of the most intricately patterned of anurans, colored in shades of brown, typically with brilliant yellow ventrally and on the concealed surfaces of the hind limbs. Color photographs are provided by Karsen et al. (1986) and a color illustration is in Lazell (1989). Four adults (YPM 5514–7), collected 16 and 21 July 1997, measured 29–31 (average 30) mm SVL. All are from Houzhai (Fig. 2:3). A juvenile (YPM 5513), collected 13 July 1997, measured 16 mm SVL. This species is documented from Nan Ao by Li and Pan (1995) and on the larger coastal islands in the Hong Kong region (Karsen et al. 1986). While it does well in edificarian habitats such

as the wet paddy, it does not seem to survive urbanization.

Microhyla ornata (Dumeril et Bibron)

This somber "pygmy" frog was not recorded on Nan Ao by Li and Pan (1995). We found it abundant at several localities on the western part of the island (Fig. 2:1, 2 and 3): YPM 5506-11. It is known from some small islets in the South China Sea (Lazell 1988b) and frequents agricultural areas (Karsen et al. 1986). Our specimens ranged from 13-18 (average 16) mm SVL.

Discussion

Our total of only 19 species for a continental shelf island the size of Nan Ao is low. Hong Kong island, much smaller in area at 78 square kilometers, has at least 58 species of reptiles and amphibians (Karsen et al. 1986). Further, Hong Kong is massively urbanized with a nearly ring-ing coastal metropolis from Victoria on the north through Aberdeen in the west to Stanley in the southeast. However, much of the interior of Hong Kong island is protected as watershed and country parks, today largely covered in some of the better (albeit mostly second growth) monsoon forest remaining in tropical China. In a very brief survey Ota and Lin (1997) record 17 species from two islands, totaling 17 square kilometers, on the continental shelf.

Despite deforestation and urbanization, we believe Nan Ao will prove to support many more species than we have recorded. We are confident that pythons, kraits and cobras are present. Indeed, we call attention to Pope's (1935:352) record of *Naja atra* Cantor

from "Lamock" island. The Le Men Lie Dao, an archipelago within Nan Ao County centered circa 10 kilometers south of the eastern end of Nan Ao, has at least four vegetated islets that might support reptiles like cobras (and certainly geckos and skinks). Cobras have been reported on Wu Yu, but a single individual may have been introduced there to discourage sea bird eggers (YL, unpubl. data). There also may be many more species of colubrid snakes. We observed two *Coluber mucosus* L. at a restaurant in Houzhai, 25 July 1996, said to have been captured locally. This snake is regularly found on coastal islands (Lazell 1988b). We saw a number of snakes we failed to catch, and our funnel traps, baited with frogs and geckos, were regularly raided, even when the raider had to regurgitate the bait to escape. On 15 July 1997 we found a road killed skink, *Mabuya longicaudata* (Hallowell), at Shen Ao. The carcass was in two pieces and discarded. We subsequently saw several more of these large, conspicuous lizards alive, but failed to catch one. We have noted above the possibility that *Eumeces quadrilineatus* may account for some of our sightings of blue-tailed skinks. Local people speak of a "fence dragon" (YL, unpubl. data). This name refers to *Calotes versicolor* (Daudin) (Agamidae) in Hong Kong.

There are two intriguing herpetological legends on Nan Ao. The first describes a small frog that lived only around one temple in the hills. Its persistent, nocturnal calling so irritated the monks that they cut its throat. Thereafter it was the only mute species of frog on the island and could be recognized by the white scar-like marking across its throat. We cannot guess this species. The second concerns the name of Gui Chen, "turtle flat" (Fig. 1:1). The site was originally a

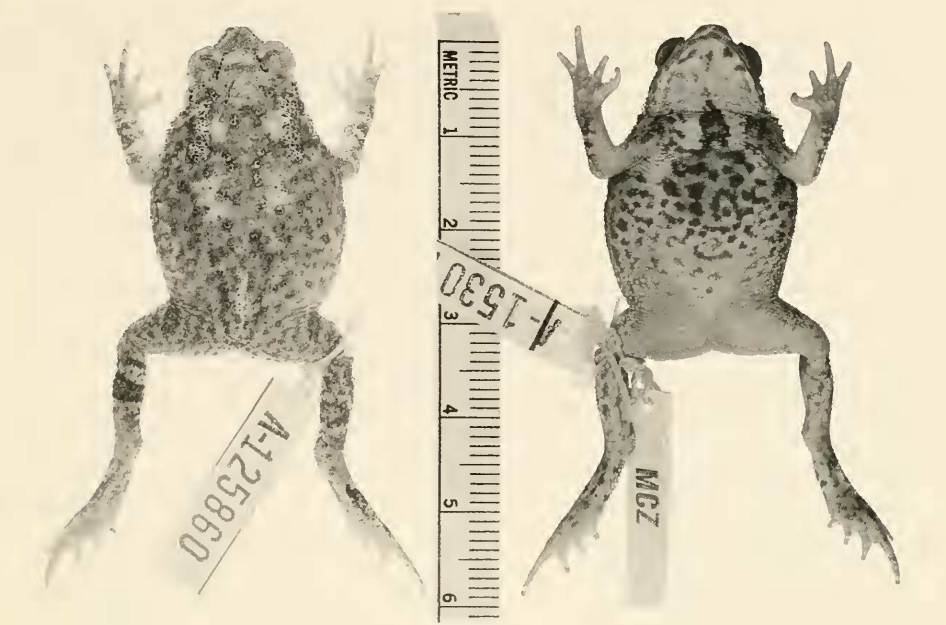


Figure 6

Bufo sp. indet., MCZ 125860, Houzhai, Nan Ao. Photographed by William K. Sacco.

marsh with ponds inhabited by the “golden coin turtle,” now believed extirpated. This name applies to *Sacalia quadriocellata* (Siebenrock), a species well known from southern Guangdong and Hainan Dao, where it inhabits streams at 100–400 m elevation (Pope 1935, as *Clemmys quadriocellata*). The name derives from the prominent, light-colored, dark-centered ocellate spots (two on each side of the head) that are rich golden yellow in young specimens.

On Nan Ao there are few natural wetland habitats left. Prior to the conversion of the mangrove swamps in the 1950s, there were several species of aquatic marine snakes with great economic value as delicacies. One, called the “round-tailed sea snake,” fits the description of *Enhydryis bennetti* (Gray), a

species we believe has been extirpated from the entire coast of China east of Hainan Dao, except at Mai Po in the Hong Kong region (Karsen et al. 1986). The effects of mangrove destruction on Nan Ao’s fisheries were catastrophic. Today, shrubs and small trees are cut to provide long rows of stakes extending into the bays at Houzhai and Shen Ao. These make a sort of artificial mangrove mimic for the cultivation of shellfish. Cutting for this purpose further hastens the deforestation of the uplands.

Although we visited more than 20 potential collecting sites on Nan Ao, we obtained specimens from only seven (Figs. 2 and 3). Of the total of 19 species collected, 17 came from three sites: the Houzhai plain, the Huanghua Shan Reservoir and Tai Zhu Ao. Of these 17, eight

were found at only one of those sites. The sites have disparate characteristics. The Houzhai plain, near sea level and with remnant freshwater wetlands, provided our only specimens of *Eumeces chinensis*, *Microhyla ornata*, *Kaloula pulchra* and the undetermined *Bufo*. The shady ravine at Huanghua Shan Reservoir, circa 200 m above sea level, was our only site for *Ateuchosaurus chinensis* and *Sphenomorphus indicus*. Tai Zhu Ao is a coastal site with an extensive paddy on the valley floor and woodlands on the flanking slopes; here we got *Elaphe radiata* and *Oligodon formosanus*. We hunted frequently at Shen Ao, for example, which is coastal with considerable freshwater wetland and paddy, and with adjacent wooded slopes, but got none of those eight species or anything unique. No doubt luck was a factor, but there may be real, highly important intraisland habitat differences too.

Plans to further develop and urbanize Nan Ao were put forward in the early 1990s (Nan Ao County Geographical Bureau 1994). A bridge, as yet incomplete, is to connect the western end of Nan Ao to the mainland. The land area is to be increased by nearly one quarter, to circa 130 square kilometers, by filling the largest bays, and four large coastal cities are planned. Already most of the agricultural area and wetland of the Houzhai plain has been graded and filled. If these plans are carried out, the impact on fauna and flora will be incalculable. We herein document several species as yet known only from the Houzhai plain, surely once the most extensive natural marshy part of this island. Some of the anurans naturally abundant in this habitat, like *Rana guentheri* and *R. limnocharis*, are desirable food items of economic value elsewhere in South China. Introduction and cultivation

of exotic bullfrogs, like staking the bays, seems a poor substitute for the native ecosystems and species lost. We did not find *Rana rugulosa* Wiegmann, a large, highly edible native species recorded by Li and Pan (1995). Its large freshwater habitats may already have been destroyed. A major effort to document the fauna and flora of Nan Ao, and the more than 20 smaller islands in Nan Ao County, is clearly called for (Qian and Lu 1994).

Acknowledgments

The late Lin Yong-Mu, our co-author, provided all our physical and most of our ecological data on Nan Ao and Wu Yu. We dedicate this paper to his memory. We are indebted to Jiang Tong, Cai Fa-sheng, Hong Sheng-qin and Zeng Li-rong (Santou University). Huang Ruo-kun, Yang Si-chang (Nan Ao County) and Li Zhen-chang (South China Normal University) provided logistical assistance to our ongoing exchange program. In the field we were ably assisted by Ben Calvi, Shannon Corliss, Phaedra Demers, Peter Lynch, Andrea Scott, Fred Sibley, Tom Smith, Carolyn Tate, Bonnie Welcker, Wu Shao Ping and Adam Young. This research was supported by Santou University, Yale University, the University of Hong Kong, the Explorers Club, the Gailer School, the Hayes Foundation, the Science and Technology Bureau of Nan Ao County and The Conservation Agency.

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